Effects of Traditional Forest Uses on the Number of Colonies of Army Ants

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Introduction

The rapid and widespread loss of biological diversity is a matter of considerable concern. Destruction of tropical rain forests, one of the most diverse terrestrial ecosystems, is one of the major factors responsible for the high rates of species extinction in recent years (Myers 1988). Globally, tropical rain forests are disappearing at a rate of 12 million ha per year (Cyranoski 2007). Furthermore, less than 5% of the total land area of tropical rainforests is protected as reserves or national parks (Western 1989). Thus, the development of methods of using tropical rain forests that can prevent biodiversity loss is urgently needed.

In Southeast Asia, swidden (slash-and-burn) agriculture has been widely used by local residents and is frequently regarded as one of the primary causes of forest degradation and loss (Freeman 1955; Lanly 1982). Others, however, have stated that traditional methods of swidden agriculture are sustainable and maintain the ecosystem because of long fallow periods as well as the complex mosaic pattern of agricultural fields, abandoned fields in various stages of forest regrowth, and primary forest (Salafsky 1993; Aumeerudy and Sanonnens 1994; Coomes et al. 2000). To better understand whether traditional swidden agriculture is sustainable in terms of conservation of biodiversity, we need to examine whether biodiversity in secondary forests recovers to initial levels following cultivation and, if so, how long it takes.

In the present study, we compared encounter rates between primary forests and secondary forests with various fallow periods for the top predator found among litter arthropods, the army ant (*Aenictus* and *Leptogenys* species). The top predator was chosen as an indicator for biodiversity loss caused by disturbance because it is vulnerable to disturbance and degradation (Noss et al. 1996) and also because it frequently plays an important role in structuring communities (Polis et al. 2000; Schmitz et al. 2000; Schmitz and Suttle 2001).

Material and Methods

Study site

The study was conducted in and around Lambir Hills National Park, Sarawak, Malaysia (4°20'N, 113°50'E; 150 to 200 m a.s.l.). Details of the park were described in Inoue et al. (1995). Local residents near the park have practiced swidden agriculture to cultivate rice and vegetables for about 100 years (Ichikawa 2002). To examine the effect of traditional swidden agriculture on biodiversity, we established two plots within the park, 11 plots in secondary forests at various developmental stages, and six plots in isolated primary forests near the park. Secondary forests were categorized into three groups depending on time since the abandonment of cultivation: new fallow (NF), <2 years after abandonment (N=3); young secondary forest (NSF), 5 years after abandonment (N=3); and old secondary forest (OSF), >20 years after abandonment

(*N*=5).

Field census

We visually located army ant colonies from August to September 2003 and from January to February in 2005. Above-ground ant foraging activity is readily detected by observers because the ants move in coordinated columns on the forest floor, tree trunks, or vines. Three 1-h searches were conducted at each plot during each census period. Censuses were performed between 0800 and 1700 hours on days with good weather. Results from the three 1-h searches were combined for analysis for each census period. Prior to analysis, the numbers of ant colonies were log-transformed (y = log [x + 0.5]) to stabilize the variances (Yamamura 1999).

Results

A total of nine *Aenictus* species was observed in 26 colonies. *Aenictus laeviceps* morphotypes L1 and L2 were the dominant species (53% of the total colonies in 2003 and 55% in 2005). *Aenictus inflatus*, *A. camposi*, *A. hottai*, and *A. cornutus* were not detected in the primary forests, and *A. gracilis* was observed only in the isolated primary forest (Table 1a). All of the *Aenictus* colonies detected in this study were on raid and no emigrating colony was observed. The number of *Aenictus* colonies differed significantly among forest types (repeated ANOVA: F = 6.42, df = 4, P = 0.004; Fig. 1a), with the highest number of colonies found in the primary forest, an intermediate number found in young and old secondary forests, and the lowest number in new fallow (Tukey-Kramer HSD: $P < 0.05$; Fig 1a). No significant differences were found between years (repeated ANOVA: F = 0.006, df = 1, P = 0.93) or for the interaction between year and forest type (repeated ANOVA: F = 2.08, df = 4, P = 0.13; Fig 1a).

For *Leptogenys*, we detected six species (36 colonies) in 2003 and four species (22 colonies) in 2005 (Table 1b). In contrast with *Aenictus*, differences in encounter rates with *Leptogenys* were not significant among forest types, although there was a weak tendency for more *Leptogenys* to be encountered in primary forests (repeated ANOVA: F = 2.43, df = 4, 14, P = 0.10; Fig 1b). No significant differences were found between years or for the interaction between year and forest type (F = 2.82, df = 1, 1, P = 0.12 for year; F = 0.25, df = 4, 14, P = 0.90 for interaction; Fig 1b).

Discussion

When *Aenictus* was used as a bioindicator, traditional swidden agriculture was shown to have a serious impact on biodiversity in the tropical rain forest of Sarawak. Once an area was farmed using swidden agriculture, the effect of the disturbance lasted more than 20 years, although some Dipterocarp trees recovered at old secondary forests (Momose et al., unpublished data). Vasconcelos (1999) suggested that ground-dwelling ant fauna recovered in as few as 25 years when the intensity of the disturbance was low, so it seems that the impact of traditional swidden agriculture on biodiversity is more severe than was previously expected. It is possible that a longer fallow period would increase the abundance of *Aenictus*. However, no *Aenictus* was detected in old secondary forests (>100 years after abandonment). Thus, it seems to be unrealistic to expect that biodiversity will be maintained by extending the fallow period.

Some *Aenictus* colonies were observed in young and old secondary forests, although in smaller numbers than in the primary forest. All of the secondary forests in which army ants were observed, except one, were located proximate to continuous primary forest. This means that remnant primary forest may have contributed to the maintenance of biodiversity in the surrounding area. In terms of managing forest usage to sustain biological diversity, our study suggested that preserving enough primary forest would be more effective than extending the fallow period after traditional swidden agriculture.

Four *Aenictus* species (*A. inflatus*, *A. camposi*, *A. hottai*, and *A. cornutus*) were observed only in secondary forests. All four species have previously been detected in a continuous primary forest (Yamane and Hashimoto 1999; Yamane, unpublished data). Therefore, it is unlikely that segregation of the *Aenictus* group occurred between forest types.

In contrast to *Aenicitus*, the number of colonies of *Leptogenys* did not differ among forest types. *Aenictus* preys exclusively on immature social insects (Gotward 1976), whereas the diet of *Leptogenys* is much broader (Maschwitz and Mühlenberg 1975; Suzzoni et al. 2000; but see Mashwitz and Schönegge 1983). Using *Eciton burchelli* and *Labidus praedator,* who prey on almost all kinds of arthropods (Rettenmeyer 1963a,b), Roberts et al. (2000) showed that the number of colonies of army ants did not differ significantly between a primary forest and a traditional shady coffee plantation. Future research is required about the relationship between the breadth of diet and the strength of tolerance to artificial disturbance among army ant groups.

Table 1a. List of *Aenictus* species encountered during the census in each forest type in 2003 (upper) and 2005 (lower)

2003		*Aenictus*								
Forest type	total	*A. laeviceps morpthotype L1*	*A. laeviceps morpthotype L2*	*A. gracilis*	*A. dentatus*	*A. inflatus*	*A. camposi*	*A. hottai*	*A. sp5 of sky*	*A. cornutus*
NF (n=3)	0	0	0	0	0	0	0	0	0	0
YSF (n=3)	0	0	0	0	0	0	0	0	0	0
OSF (n=5)	1	0	0	0	0	1	0	0	0	0
IPF (n=6)	9	3	2	2	1	0	0	0	0	1
CPF (n=2)	5	2	1	0	1	0	0	0	1	0

2005		*Aenictus*								
Forest type	total	*A. laeviceps morpthotype L1*	*A. laeviceps morpthotype L2*	*A. gracilis*	*A. dentatus*	*A. inflatus*	*A. camposi*	*A. hottai*	*A. sp5 of sky*	*A. cornutus*
NF (n=3)	0	0	0	0	0	0	0	0	0	0
YSF (n=3)	2	0	0	0	0	1	1	0	0	0
OSF (n=5)	2	1	0	0	1	0	0	0	0	0
IPF (n=6)	4	1	1	0	0	1	0	1	0	0
CPF (n=2)	3	2	1	0	0	0	0	0	0	0

NF, YSF, OSF, IPF, CPF designated new fallow, young secondary forest, old secondary forest, isolated primary forest, and continuous primary forest, respectively. See M&M for the definition of each forest type.

Table 1b. List of *Leptogenys* species encountered during the census in each forest type in 2003 (upper) and 2005 (lower)

2003	*Leptogenys*						
Forest type	total	*L. processionalis*	*L. diminuta*	*L. sp39 of sky*	*L. sp 6 of sky*	*L. mutabilis*	*L. chalybaea*
NF (n=3)	5	4	1	0	0	0	0
YSF (n=3)	1	0	0	1	0	0	0
OSF (n=5)	10	5	1	4	0	0	0
IPF (n=6)	11	2	5	3	1	0	0
CPF (n=2)	9	3	3	1	0	1	1

2005	*Leptogenys*						
Forest type	total	*L. processionalis*	*L. diminuta*	*L. sp39 of sky*	*L. sp 6 of sky*	*L. mutabilis*	*L. chalybaea*
NF (n=3)	2	2	0	0	0	0	0
YSF (n=3)	1	0	1	0	0	0	0
OSF (n=5)	5	2	2	1	0	0	0
IPF (n=6)	7	2	3	2	0	0	0
CPF (n=2)	7	3	2	1	0	0	1

NF, YSF, OSF, IPF, CPF designated new fallow, young secondary forest, old secondary forest, isolated primary forest, and continuous primary forest, respectively.
See M&M for the definition of each forest type.

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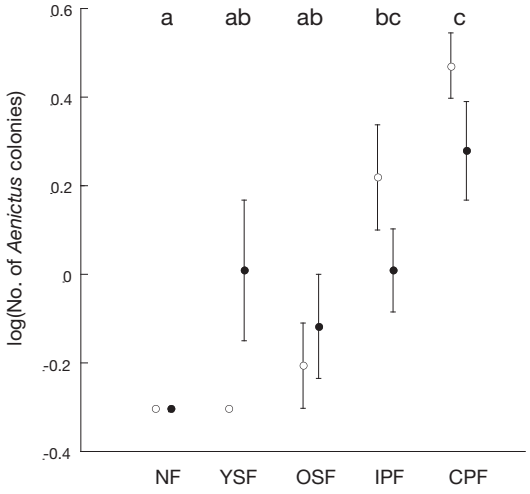

Figure 1a. Mean (±S.E.) of log-transformed encounter rates with *Aenictus* species within each forest type in 2003 (open circle) and 2005 (solid circle). Different letters among circle designated significant difference among forest types. NF, YSF, OSF, IPF, CPF designated new fallow, young secondary forest, old secondary forest, isolated primary forest, and continuous primary forest, respectively. See M&M for the definition of each forest type.

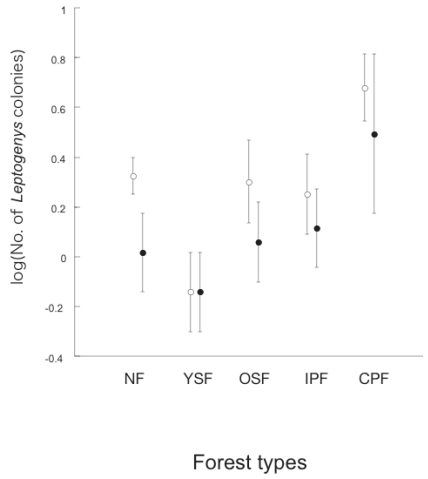

Figure 1b. Mean (±S.E.) of log-transformed encounter rates with *Leptogenys* species within each forest type in 2003 (open circle) and 2005 (solid circle). NF, YSF, OSF, IPF, CPF designated new fallow, young secondary forest, old secondary forest, isolated primary forest, and continuous primary forest, respectively. See M&M for the definition of each forest type.